U. S. DEPARTMENT OF AGRICULTURE

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DRY FARMING IN WESTERN SOUTH DAKOTA

GRAIN CROPS in western South Dakota, in the average results of a series of years, show yields that should be profitable; but a stable agriculture based upon grain production alone has not been established. The average is made up of exceedingly heavy yields in a few years and low yields or failure in other years, rather than fairly good yields each year. Grain farming has not been able to withstand the reverses of the unfavorable years, which may appear in succession, and to realize the profits of the good years.

The United States Department of Agriculture, since 1908 at the Belle Fourche Field Station, near Newell, and since 1912 at the Ardmore Field Station, has been conducting thorough investigations of methods of crop production in western South Dakota. The results of these investigations show that the high fluctuation of yields, due to fluctuating rainfall, can not be sufficiently overcome by cultural methods to change the problem materially. These results and the experience of farmers who have succeeded indicate that the most favorable conditions for grain production are found when combined with or subordinated to stock production.

The system and methods recommended are (1) keeping livestock to the capacity of summer pasture and winter feed, (2) the growth of cultivated annual crops (corn and sorgo) for winter feed, and (3) the growth of small grains following the corn without plowing. This system may be modified as local or individual conditions warrant the growth of alfalfa for hay or seed, or the growth of a larger acreage of wheat or other grains.

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DRY FARMING IN WESTERN SOUTH DAKOTA

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AGRICULTURAL CONDITIONS

WESTERN SOUTH DAKOTA is largely a dry-farming country. With the exception of the Black Hills and a narrow belt of land adjacent to and influenced by them, it lies within a region normally deficient in rainfall. A certain part of this territory is irrigated, and more will no doubt eventually be reclaimed, but most of it must always be dry farmed.

Attempts to make this part of South Dakota a strictly crop-producing section have been unsuccessful. The settlement of this country has generally been made after a series of good years had created an exaggerated idea of its crop possibilities. Most of the original settlers tried to make a living by crop production, and almost all of them failed and left the country. Only those who turned to the raising of livestock as their principal industry have been able to remain.

Although crop production alone has not been successful, the growth of a certain proportion of crops is necessary to the best development of the livestock industry. This bulletin, in reporting the results of studies of methods of crop production, indicates a way in which the two can be combined to make each successful. It is based upon the results obtained on the dry-farming unit of the Belle Fourche Field Station, near Newell, S. Dak., established in 1908, supplemented by those of the Ardmore Field Station, established in 1912. At both stations all the adapted crops have been under trial each year under all the combinations and methods likely to be practiced or offering a possibility of success.

TOPOGRAPHY

Most of western South Dakota is a Plains section. There are portions that are too rough for cultivation, but by far the larger part is physically suited to the raising of crops. Much of it consists of rolling hills whose slopes are generally not too steep to be cultivated.

Economic conditions that will decide how much of the land can be profitably cultivated, rather than the topography of the country, will determine the area of land devoted to crops.

SOILS

The soils of western South Dakota vary from almost pure sand to a very heavy clay, or "gumbo." The Pierre clay, or "gumbo," soil constitutes about one-third of the area of South Dakota west of the Missouri River. The Belle Fourche Field Station is situated on this type of soil, and the results at this station are to be applied to this soil in particular. It is on soil of this type that dry farming is the most difficult and that crop production is the least successful. Both the expense of working the soil and the fact that crops show less drought endurance on this heavy soil than on lighter soils contribute to this result. So far as soil conditions are concerned, the lighter the soil the more certain crop production should be, provided the soil is not so light that soil blowing becomes a factor. The lighter soil will probably not produce as high yields as the heavy soil in favorable years, but will endure more drought and produce better yields in years of partial failure. Average yields obtained at Newell are doubtless lower than would be obtained in more favorable soils in western South Dakota.

The station at Ardmore is located in a soil of heavy clay type, but deeper and somewhat lighter than the "gumbo" of the station near Newell.

CLIMATE

The average annual precipitation in western South Dakota, exclusive of the area influenced by the Black Hills, varies from 13 to 18 inches. At both Newell and Ardmore about two-thirds of the total precipitation occurs during the five months from April to August, inclusive. The precipitation during the growing season, like the annual precipitation, is variable in both quantity and distribution. Both of these factors are of great importance in determining crop production. Low seasonal rainfall is usually accompanied by high evaporation and possibly by unfavorable temperatures and hot winds. The same may be true of a seasonable precipitation normal in quantity but not well distributed. A well-distributed seasonal rainfall of average or more than average amount is usually accompanied by favorable growing conditions.

Only in exceptional years is the precipitation high enough and sufficiently well distributed to allow all crops to mature without their growth being checked to some extent by drought. Likewise it is rare for any year to be so dry that complete failure of all crops occurs.

In most years there is drought injury, varying in extent with the amount and distribution of the precipitation and with the intensity of other climatic factors. This injury seldom affects all crops equally. A complete failure of small grains, which make their growth early in the season, may occur in a year when good yields of late-growing cultivated crops are obtained, or a good yield of small grain may be obtained in a year when cultivated crops do not do well.

The distribution of rain through the growing season is usually the deciding factor in determining which crops will be successful in any

given year. The fact that one crop may do well in a year when another crop fails tends to make some diversification of crops necessary, in order that complete failure may be avoided as far as possible.

The amount and the distribution of the precipitation are well shown in Table 1, compiled from the records of the Belle Fourche Field Station. The precipitation at Ardmore is about the same, the average for the 14-year period from 1912 to 1925, inclusive, being 16.43 inches, or only 0.19 inch less than the average at Newell for the same years.

TABLE 1.—*Precipitation at the Belle Fourche Field Station, Newell, S. Dak., for the 18-year period from 1908 to 1925, inclusive*

[Data in inches; T.=trace]

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1908	0.20	0.19	1.65	1.16	3.95	1.47	1.26	0.62	0.52	2.03	0.20	0.91	14.16
1909	.17	.23	.19	.84	3.87	5.59	2.45	.55	1.07	.76	.73	1.28	17.73
1910	.73	.70	.93	1.57	1.26	1.51	1.42	1.03	2.92	.27	.11	.10	12.55
1911	.13	.05	.09	.17	.45	.50	.80	1.86	.92	.39	.98	.30	6.64
1912	.24	.10	.71	2.32	2.26	.29	3.20	2.80	3.49	.51	.04	.13	16.09
1913	.57	.24	.99	.25	1.98	3.10	.35	.26	2.38	1.86	.10	.45	12.53
1914	T.	1.00	.29	1.09	2.22	2.09	1.34	1.12	.35	1.77	0	.43	11.70
1915	.92	1.01	.16	2.58	2.32	4.74	5.74	.44	1.26	1.25	.43	.17	21.02
1916	.36	.23	.98	.64	3.17	2.19	2.01	2.02	.20	.99	.33	.28	13.40
1917	.92	.74	.27	2.51	3.71	.97	.80	1.67	.35	.46	T.	.92	13.32
1918	.99	.64	.81	2.40	1.60	1.17	3.41	2.99	3.08	.22	.15	.85	18.31
1919	.04	.57	.87	2.14	1.14	.35	2.59	1.02	1.20	2.49	1.22	.62	14.25
1920	.65	.16	1.35	2.59	8.35	5.90	2.53	.56	.63	1.67	.55	.95	25.89
1921	.29	T.	.84	.72	1.44	3.36	2.30	.52	.72	.10	.30	.50	11.09
1922	1.31	.38	.20	2.84	3.42	3.74	6.52	.90	T.	.79	2.82	.24	23.16
1923	.22	.23	.32	.82	2.31	3.81	4.54	5.35	5.95	3.14	.27	.41	27.37
1924	.08	.88	.70	.81	.68	1.27	1.22	2.00	.72	3.86	.93	.65	13.80
1925	.33	.21	.18	1.53	1.55	3.10	.39	.76	.65	.96	.19	.91	10.76
Average	.45	.42	.64	1.50	2.54	2.51	2.38	1.47	1.47	1.31	.52	.56	15.77

CROP PRODUCTION

Water stored in the soil at seeding time is used by the crops, and to the extent to which it is needed and is able to supplement the rainfall may determine the yield, but in this region it is not sufficient in itself to produce crops. Production is dependent upon the rainfall of the season in which the crops are growing. It is consequently impossible to tell from the character of the winter or from the amount of precipitation before seeding what the chances of success with the different crops may be.

Thus, the choice of crops, aside from winter wheat, in any given year should not be influenced to any great extent by conditions before seeding. The best farm practice is to select the crops that have shown the best average results for a number of years and devote a certain area of land to these each year rather than to try to base the acreage to be devoted to crops and the kind of crops to be grown upon conditions prevailing before seeding in any year.

Successful crop production in western South Dakota must embody the following: (1) The selection of crops best adapted to the locality and the best varieties of these crops, (2) the use of cultural methods that will give the greatest return for labor in the production of these adapted crops, and (3) the adoption of a system of farming in which crop production supplements the other lines of farm activities.

ADAPTED CROPS

The crops adapted to western South Dakota consist principally of small grains, cultivated crops, and pasture and hay crops. These will be considered separately.

SMALL GRAINS

The production of small grains at both the Belle Fourche and the Ardmore Field Stations has been uncertain in the extreme, though in the average of a series of years most grain crops have shown profitable yields. Analysis of the results shows that the fairly good average yield is the result of high yields in good years and low yields in other years rather than of fairly good yields each year. The average yields of winter wheat, spring wheat, oats, barley, corn, and sorgo at the Belle Fourche Field Station and at the Ardmore Field Station are shown in Table 2. The yields given are the averages of all methods under trial and represent an approximately equal number of the better and poorer yielding methods. They are probably above the averages obtained by all farmers, but it ought to be possible for farmers using only the best methods to equal or exceed them.

TABLE 2.—*Yields of winter wheat, spring wheat, oats, barley, corn, and sorgo at the Belle Fourche and Ardmore (S. Dak.) Field Stations for certain years in the 17-year period from 1909 to 1925, inclusive*

Station and year	Winter wheat	Spring wheat	Oats	Barley	Corn		Sorgo, total
					Grain	Stover	
Belle Fourche:	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Pounds*	*Pounds*
1909	28.9	28.7	60.9	31.7	19.3	3,305	5,920
1910	1.8	2.6	6.8	3.0	.6	2,839	3,360
1911	0	0	0	0	0	0	0
1912	0	0	8.2	.7	21.9	2,623	4,100
1913	21.3	10.8	23.9	10.1	8.6	986	3,400
1914	18.2	10.1	26.3	9.5	.5	1,115	1,725
1915	36.2	57.6	125.6	72.2	44.5	2,785	6,450
1916	12.7	17.3	33.3	31.0	32.5	2,198	9,650
1917	3.8	7.4	17.1	22.9	20.4	1,969	3,300
1918	27.1	11.9	23.3	14.6	30.0	2,977	7,700
1919	2.0	.9	2.3	1.3	.3	235	0
1920	1.6	29.9	63.8	60.9	37.4	2,008	5,900
1921	5.4	7.3	11.6	12.8	9.0	1,435	2,450
1922	30.8	32.2	66.0	44.8	42.3	3,069	5,950
1923	21.3	28.0	57.5	47.9	52.4	3,379	7,820
1924	30.5	21.5	44.1	28.3	17.7	1,122	3,540
1925	23.6	19.8	52.2	32.3	9.0	1,710	4,640
Average	15.6	16.8	36.6	24.9	20.4	1,986	4,465
Ardmore:							
1913	1.4	2.0	2.3	1.4	0	927	----------
1914	0	0	0	0	0	1,013	----------
1915	33.2	46.8	77.2	52.9	38.8	3,669	----------
1916	31.3	21.1	39.8	23.4	22.1	3,025	6,240
1917	7.2	9.2	15.2	5.3	13.9	1,410	3,100
1918	19.4	35.0	65.1	39.9	22.2	2,110	6,700
1919	18.3	11.6	22.4	8.6	9.2	1,524	3,964
1920	25.7	28.1	56.8	35.1	19.3	1,660	4,040
1921	16.0	18.6	42.5	14.4	7.9	1,976	4,290
1922	0	0	0	0	14.8	1,386	4,300
1923	17.4	24.4	59.1	43.5	29.5	2,607	7,180
1924	9.3	11.9	13.3	11.2	2.4	1,978	2,090
1925	[1] 10.2	17.1	33.6	32.3	13.0	2,013	3,940
Average	14.6	17.4	32.9	20.6	14.9	1,946	4,584

[1] Yield from reseeding to spring wheat.

The yearly results in Table 2 show why grain farming in this section has not been successful. The average yield of spring wheat at the Belle Fourche Field Station has been 16.8 and at Ardmore 17.4 bushels per acre. If it were possible to obtain these yields of wheat each year, wheat raising could be made a profitable type of farming. However, in 9 of the 17 years at Belle Fourche and in 6 of the 13 years at Ardmore the yield of wheat has been considerably below these averages, and in these years wheat has been grown either at a loss or at a very small profit. As many as three years of nearly complete failure have occurred successively. This explains why wheat production has been an unstable type of farming.

Wheat raising alone is not successfully maintained where in so large a proportion of the years it must be carried on at a loss or at a very small profit. It can, however, be carried on profitably in connection with livestock production, provided it can be handled in such a way as to require a minimum of labor and expense.

The same is true of oats and barley. Their yields have been relatively about the same as that of spring wheat, and the drought resistance of the three has been practically the same. Choice between these three crops must depend primarily upon individual conditions that determine which crop can be most profitably disposed of.

Winter wheat survives the winter in only a small portion of western South Dakota. When it endures, it may produce a higher yield and be more profitable than spring wheat. When it winterkills, the land can be reseeded to spring wheat or some other crop without any further expense than seed and seeding. When there is not sufficient moisture in the soil in the fall to insure germination of the seed, the planting of winter grains is not advisable.

Winter rye has not been so profitable as winter wheat in the section where winter wheat does well. It is, however, more hardy and will endure the winter in any section of the State. Over most of western South Dakota it is generally as profitable as the spring grains. It ripens earlier in the season and consequently often escapes periods of drought that affect spring-seeded crops. For this reason it is a more dependable crop than the spring grains, though its yield does not compare favorably with theirs in years of high production.

The yields of flax at these stations have not been high. Flax has been generally grown as a sod crop on new breaking, and in this connection has given poor yields. Flax on old ground or upon land broken the previous summer has given better results, but even then has not been so good as other grain crops. It is particularly adapted for growth where a cash crop is desirable and where a long haul to market is necessary. Its high price in proportion to its bulk makes it a valuable crop in this connection, even though the weight of the product per acre is relatively smaller than that of other grains.

The best varieties of these different grain crops and the best time and rate of seeding recommended as a result of extensive tests conducted by the Office of Cereal Crops and Diseases, Bureau of Plant Industry, are stated in Farmers' Bulletin 878, "Grains for Western North and South Dakota,"[1] as follows:

Varieties.—Winter wheat (in the vicinity of the Black Hills), Kharkof, Turkey; spring wheat, Kubanka, Marquis; oats, Kherson, Sixty-Day; barley,

[1] By F. Ray Babcock, John H. Martin, and Ralph W. Smith.

White Smyrna, Hannchen; rye, North Dakota No. 959, Swedish; flax, North Dakota No. 155, Damont.

Time of seeding.—Sow spring wheat and oats as early as the land can be put in good condition, barley after wheat and oat seeding is finished, and flax about May 1. Sow winter wheat and winter rye in late August or early September in North Dakota and in September or early October in South Dakota.

Rate of seeding.—The best rates of seeding are as follows: Spring wheat, 4 pecks per acre; winter wheat, 3 to 4 pecks per acre; oats and barley, 5 to 6 pecks per acre; flax, 20 to 30 pounds per acre.

CULTIVATED CROPS

Corn is the cultivated crop grown most generally in western South Dakota. There are varieties that will ripen in all parts of this section. A yield of grain can not be obtained every year, but a yield of fodder is fairly certain. Sorgo is the only other crop that offers possibilities of competing with corn as a coarse feed crop in this section. Table 2 presents the average annual yields of both corn and sorgo at both the Belle Fourche and the Ardmore Field Stations. This table shows that at each station corn has produced a good crop of grain in about half the years. At Ardmore there has been some crop, at least of stover, every year, but at Belle Fourche there was complete failure in 1911 and a failure from most methods in 1919. In both years the ground was so dry at corn-planting time that the seed did not germinate. Sorgo failed in those years at Belle Fourche for the same reason.

The greatest value of corn as a dry-land crop is its ability to produce a fair yield of stover even in dry years. Corn fits in admirably with the raising of livestock and can be depended upon to produce winter feed for them in most years so dry that the growth of grass on the prairie is scant and opportunities for cutting hay are limited. In addition to this, corn in more favorable years produces a fairly good yield of grain. The combined value of the grain and stover tends to make corn the most profitable dry-land crop in this area. As the number of stock in the section increases and the area of land where hay can be cut becomes smaller, farmers will be more and more dependent for their winter feed upon crops like corn that produce a large yield of rough feed per acre.

Sorgo produces a higher yield of stover per acre than corn over most of western South Dakota, and the stover is more palatable. It does not appear likely, however, to replace corn to any considerable extent in this section. The combined value of the grain and stover of corn is greater than the stover value of sorgo. This, together with the fact that corn is easier to produce, makes it seem certain that corn will continue to be the leading cultivated crop. It is worthy of note, however, that in a considerable number of years at both the Belle Fourche and Ardmore stations when the yield of ear corn was low, the yield of sorgo was proportionately greater than in more favorable years. A portion of the corn acreage could well be replaced by sorgo as an insurance against failure of the feed crop in unfavorable years.

The varieties of corn best suited to western South Dakota vary with the locality. Near the northern part of the State, only very early corn will mature. In the central and southern portion the earlier dent corns, such as Northwestern and Payne White, have been most successful. In many places some unnamed varieties have

been grown in restricted localities for a number of years. In most cases adapted acclimated varieties like these are as valuable as the standard varieties that are more widely known.

Only the sweet sorgos are adapted for growth as far north as South Dakota. Minnesota Amber, Dakota Amber, and Red Amber are the most promising varieties.

PASTURE AND HAY CROPS

At least in the "gumbo" soils of western South Dakota the growth of pasture crops has not been and is not likely to be practiced. The expense of preparing the ground and seeding a pasture crop, together with the fact that a comparatively large acreage is required for each animal pastured, makes the initial cost almost prohibitive.

Alfalfa and brome grass offer possibilities as hay crops. The yield of feed is much less per acre than that of corn and similar crops, but there is an advantage in that they do not need to be planted each year. Alfalfa at least will endure for an indefinite number of years. It will produce a cutting practically every year, though the growth may be checked by drought before the alfalfa comes into bloom. Three cuttings have been produced at the Belle Fourche Field Station in only one year and two cuttings in three other years. In one year, 1911, the crop was a total failure. At the Ardmore Field Station it has failed twice and produced two crops twice.

Alfalfa is particularly adapted for growth along streams or on bottom lands where the ground water is within reach of the roots. Under conditions like this it will make two or three cuttings each year. Brome grass is particularly adapted to places that receive considerable run-off. In such situations it can be depended upon to produce one good-sized crop of hay each year until it becomes sod bound. The greater feeding value of alfalfa and the fact that it produces nearly as much hay as brome grass and does not become sod bound make it much more valuable as a hay crop.

In addition to its value as a forage crop, alfalfa is often of great value as a seed crop. In years when seed production is good, the value of the seed is usually far greater than that of the forage. When a seed crop is obtained, the straw from which the seed has been separated is readily eaten by stock and has a greater nutritive value than grain straw.

The ability of alfalfa to produce seed depends to a great extent upon the type of soil upon which it is grown. On the heavy clay soils, like that at Belle Fourche, alfalfa seldom produces seed after it has once been established, even when grown in cultivated rows. The plant generally begins to suffer from drought before it comes into full bloom, and little seed is formed.

On lighter soils alfalfa suffers less severely from drought and produces seed in most years if it is grown in cultivated rows or broadcast with a very thin stand. Culture in rows is the surest method of producing seed, but the expense of cultivation reduces the profit from this method to some extent. Practically the same forage yield is secured from alfalfa in cultivated rows and that sown broadcast.

On soils where ground water is within reach of the roots a seed crop is obtained nearly every year. Where this condition exists no

advantage is to be gained by growing in cultivated rows. Either the first or the second cutting may be left for seed. When the second cutting is left for seed, a cutting of hay is obtained in addition to the seed crop.

With the exception of land where the ground water can be reached by the roots, alfalfa seed production is not sufficiently certain to become a part of any definite farming system. However, on the lighter soils of western South Dakota a certain part of the land can be planted to alfalfa to very good advantage. In years of good seed production the alfalfa can be saved for seed. In years when it seems apparent that little seed will be formed, the crop can be cut for hay. Used in this way, it will be valuable in all years except those of complete failure.

The variegated alfalfas—Grimm, Baltic, and Cossack—have shown slightly better yields and greater hardiness than common alfalfa.

CULTURAL METHODS

The cultural methods that have been under trial consist of spring plowing, fall plowing, disking, listing, subsoiling, summer tillage, and the plowing under of green-manure crops.

The number of tillage operations required for preparing the land for a crop varies a great deal with these different cultural methods. The time at which the labor must be performed likewise varies. The tillage operations involved in each method of cultivation and the time at which they may be best performed are as follows:

Spring plowing for all small grains should be done as early as weather conditions will permit. Plowing to a depth of 4 to 6 inches is advisable. The land should be disked before it has a chance to dry out and harrowed at least once after plowing. Spring plowing for corn may be delayed until after small grains are seeded.

Fall plowing may be done at any time after harvest. From 5 to 8 inches constitutes a good depth. As the land is usually dry in the fall, it is best to leave it rough until spring. A double disking and a harrowing in the spring are all the preparation necessary before seeding small grains. Where a later seeded crop is to be planted, additional cultivation may be required in order to keep the land free from weeds until seeding. Fall plowing offers a better distribution of labor than spring plowing.

Disking without plowing at the Belle Fourche and Ardmore stations has been practiced only for small grains and only on land where an intertilled crop has been grown. Double disking and harrowing in the spring are all the preparation required before seeding.

Listing for small grains may be done at any time after harvest. The lister should be run a little deeper than for planting corn, and the furrows should be about the same distance apart as for corn. The land may be left rough over winter and worked down level in the spring. Normally, two diskings and a harrowing are required. Listing for corn is usually done with a lister planter. No cultivation before planting is required where corn is planted in this manner.

Subsoiling is done at the same time as fall plowing. The land is plowed with an ordinary plow to a depth of 8 inches, and a subsoil plow is run in alternate furrows to an additional depth of 8 inches,

making a total depth of 16 inches. As the time and labor necessary for plowing with the subsoil plow are at least as great as for original plowing, the cost of the whole operation is practically that of two plowings. The spring cultivation needed for subsoiled land is the same as for land given an ordinary fall plowing.

Land to be summer-fallowed should be plowed about 8 inches in the spring or early summer, worked down immediately after plowing, and kept free from weeds during the rest of the season. This usually requires at least two diskings and several harrowings. The disk and harrow, however, may well be replaced by sweep or shovel cultivators of the duck-foot type. Recent experiments have even shown the possibility of omitting the plowing when such cultivators are used. They are efficient in preventing weed growth and leave the surface granular and ridged. This condition facilitates the penetration of water and protects against soil blowing. Fallowing requires the use of the land two years for the production of one crop and, consequently, is an expensive method.

Green manuring is the most expensive method that has been tried. It involves the preparation of land for the green-manure crop, the cost of seed and seeding, the plowing under of the green-manure crop, and the keeping of the land free from weeds the rest of the season. Usually two plowings, at least two diskings, and two or more harrowings are required. The loss of the land for a year is also an item of expense in preparing land by this method.

The different crops vary in their response to these cultural methods. For this reason grain crops, cultivated crops, and hay crops are considered separately.

SMALL GRAINS

The results at the Belle Fourche Field Station indicate clearly that the most profitable crops of grain are produced by the cheaper methods of soil preparation. Grain on disked corn land or on disked land where some other cultivated crop has been grown has shown the highest net profit of any method of soil preparation tried. This is due largely to the low cost of production, but partly to the fact that disked cultivated land has generally produced yields above the average. The yields of wheat, oats, and barley on disked corn land have been higher than the yield of the same crops on spring or fall plowed corn land. In other words, plowing corn land either in the spring or in the fall has been accompanied by an actual loss in yield, as well as by the increased cost of production due to the plowing. It must be borne in mind that the corn ground had been kept free from weeds. If weeds had been allowed to grow, the results probably would not have been so favorable. With the corn ground kept clean, the production of grain on the disked corn land is by far the most profitable method of production that has been tested.

Spring and fall plowing are about equal as methods of land preparation for grain. Practically the same amount of labor is necessary for the preparation of a seed bed, and when seeding is done at the same time the yields produced are nearly the same. Fall plowing can be done at a time when work is not so pressing, consequently it has an advantage over spring plowing in that respect. As seeding can be started as early as plowing, fall-plowed land can be seeded

earlier than land that must be plowed in the spring. This consideration becomes most important in seasons when unfavorable weather conditions hinder spring work. This is a decided advantage for fall plowing, because early-seeded crops mature earlier and as a result often escape periods of drought that injure later seeded crops. However, if the conditions in the fall are such that plowing can not be done, a farmer may do his plowing in the early spring and be assured of practically the same returns as when land has been plowed in the fall, provided seeding is not unduly delayed.

Plowing is more expensive than disking in preparing land for grains. When small grains follow corn, better yields are obtained by disking. Plowing grain stubble is recommended for use only in the sections of western South Dakota where grain growing is most successful and where the desired grain acreage is greater than the area devoted to corn. Over the area represented by the station near Newell the yields are so low that the production of grain, other than on disked corn land, is more likely to result in loss than in profit.

The yields of grain on listed land compare favorably with those on plowed land. The cost of production on listed land is slightly lower, so the net return is a little higher. The difference in return, however, is not great enough to justify the purchase of any special equipment for growing grains on listed land.

The more intensive methods of cultivation, such as fallowing and plowing under green-manure crops, have not proved profitable in grain production. The yield of grain has been increased both by fallowing and by the plowing under of green-manure crops. In but few cases has the increase been large enough to pay for the added expense. In years of high rainfall other methods are as good; in years of low rainfall all methods fail; only in some years of partial failure do these methods show to advantage. On an average, their use over the period covered by the experiments has resulted in a smaller profit for fallowing than for cropping each year and a net loss for plowing under green-manure crops.

Subsoiling and deep tillage have neither increased nor decreased yields to a measurable extent. They have simply added to the cost of producing grains without adding to the value of the crops produced. Consequently these practices have been less successful than cheaper methods of cultivation.

Intensive tillage methods can not be expected to pay in a section where the net profits per acre are low and where yields are not greatly increased by their use. The same amount of labor distributed over more acres would be a more profitable investment.

Subsoiling, green manuring, and fallowing are not recommended as general practices for any section of western South Dakota.

CULTIVATED CROPS

Spring and fall plowing have given about equal results as methods of soil preparation for corn. Fall plowing requires a little more cultivation in that a certain amount of spring cultivation is necessary in order to keep the land clean until the corn is planted. It has a slight advantage in that the corn usually comes up a little sooner and matures just a little earlier. There is no great difference

in yields, and the farmer may arrange to do his plowing at any time previous to planting without materially affecting the yield.

Listing for corn has given lower yields than spring or fall plowing. The low cost of land preparation, however, makes the net profit per acre fully as high. In spite of this, listing is not likely to meet with favor in western South Dakota. Corn on listed land has a tendency to come up a little more slowly and to mature a little later than corn on plowed land. There is also some difficulty in obtaining a stand.

The more intensive methods of tillage have shown less response with corn than with small grains.

Fall plowing has been superior to spring plowing as a method of land preparation for sorgo. The difference has been largely due to stand. Spring-plowed land of the heavy clay type can not always be worked down to form a good seed bed for sorgo, because of its tendency to remain lumpy until mellowed by rains. In seasons that are dry between plowing and planting time, the fine seed bed necessary to give a good stand of sorgo can not be obtained.

HAY CROPS

Hay crops, such as alfalfa and brome grass, are not adapted for use in rotations. They should be seeded in spring or early summer on land fall plowed, worked down to form a solid seed bed in spring, and kept free from weeds until seeding. After a stand of these crops has been obtained they should not be plowed up, but should remain intact as a hayfield so long as the production remains good. Brome grass may be pastured to good advantage for several years after it becomes so sod bound that it no longer produces a profitable yield of hay. Crops following alfalfa and brome grass are usually poor, on account of the extremely dry condition in which the soil is left.

THE BEST SYSTEM OF FARMING

The system of farming that offers the greatest possibility of a permament agriculture for western South Dakota is one in which crop production is combined with the raising of livestock. Crop production alone can not be depended upon for a successful type of farming, as the cash crops, such as small grains, are subject to failure and the margin of profit is low. The more certain crops, such as corn stover and sorgo, can not be grown with profit unless fed near where they are produced. Their bulky nature prevents long hauls, and their sale price is far below their feeding value. The production of livestock alone is likewise subject to limitations. The most prominent of these is the question of winter feed. In dry years the growth of grass on the Great Plains is scant, and the quantity of hay that can be cut is limited. Unfortunately the livestock need the most land for pasture in the particular seasons when the acreage that must be cut for hay must be extended if an adequate supply of winter feed is to be obtained. The best way to meet this condition is to grow some annual crop, such as corn, that produces a comparatively large bulk of rough feed per acre.

The system of farming that suggests itself is as follows: (1) The production of livestock up to the limit of pasture in dry years, (2) the planting of an acreage of corn sufficient to meet the winter demands of the stock to be carried over, and (3) the production of small grain on the corn land.

The limit of livestock production for any one farmer lies primarily in the area of pasture land he has after an acreage sufficient for growing crops has been set aside. The number of livestock that should be kept should be limited by the extent of pasture available in a dry year rather than by that of a favorable season. It is better to undergraze land in good seasons than to overgraze it in years of drought. The carrying capacity of different sections varies with the native vegetation. What the carrying capacity of any particular section is must be determined by observation and experience.

Corn stover offers a solution of the question of winter feed. As has been shown in considering corn and sorgo, they can be practically relied on to furnish the rough feed each year. Ear corn is produced in paying quantities in more than half the years, and when obtained it can be well utilized either for feed or for sale. Since corn does well on either spring or fall plowing, the work preparatory to planting can be done at the time when it interferes least with other farm work. The acreage of corn and sorgo grown should be sufficient to insure winter feed for the livestock to be carried over. The acreage should be fixed by the quantity necessary for winter feed in years when the production of stover is not high. In years of extra-heavy production the excess feed can be carried over or the number of stock increased for winter feeding.

Although corn and livestock must form the basis of a permanent agriculture in this section, grains can be grown in connection with them as a speculative crop, with the chances of profit very good and the chance of total failure low. The corn ground provides one of the best preparations for small grains, on which they can be grown at a very low cost. Their yield, consequently, does not need to be heavy in order to be profitable. In years of high production they are very profitable. The land planted to corn in one year may be planted to small grain the next without expense other than disking, harrowing, seed, and seeding. In years when the conditions favor grain production, the value of the grain crop far exceeds the cost of production. In years when it seems apparent that no grain will be produced, the small-grain crops may be cut for hay and a supplemental supply of winter feed thus procured. This will make the grain crops of value in seasons when their production for grain is a failure. As has been stated, the corn should be kept clean. The cost of keeping the corn free from weeds is more than made up in the added value of the following crop. The kind of small grain to be raised must depend upon the needs of the individual farmer.

With modifications, this system of farming should be adapted to any part of western South Dakota. In places where grain does well, the acreage of small grains may exceed the corn acreage. The extra acreage of small grain will then be grown on either spring or fall plowing following small grain. On farms where particular land conditions, such as land along streams, favors the growth of alfalfa and brome grass, the acreage of corn grown may be reduced. With

modifications to meet special conditions, such a combination of crop growing with livestock production holds promise of forming the basis of a stable system of farming for western South Dakota.

The climatic records available cover a much longer period than those of crop production. They show that such extreme years as 1911 are very infrequent. Such years, as well as less extreme ones like 1919, may be provided against in part by a liberal carry over of surplus feed from years of heavy production. They must be met in part by the importation of feed and in part by the temporary reduction of herds and flocks. The essential thing is that farms be so capitalized that they can stand the strain of such reverses and continue as going concerns prepared to obtain the returns of the good and the average years.

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